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CORRECTION

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The B.S.I. approved common name for 2,4-DP is dichlorprop, not decoprop as given at the beginning of the article "Malformation of Cereals caused by Growth Regulator Herbicides", page 16.

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Small Farmers and their Way of Life in South-west Shropshire

A. R. STANIFORTH

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A SURVEY has recently been published of 1,400 small farmers in mid-Wales and their farming economy.* The present article changes lenses, as it were, to focus on a circle of small farms in four parishes in the south-west corner of Shropshire, in order to show more detail of their way of life and the manner in which this affects the adviser in his work.

There are (at the time of writing) 28 small livestock rearing farms in the Small Farmer Scheme in these parishes, almost all lying between the 900 and 1,300 ft contours and in the 35–45 in. rainbelt. The District Advisory Officer completed questionnaires while on routine visits to these farms, with the help of information freely given. Many of the names of the farms, as well as of the farmers, are Welsh, but no-one can recall a time when Welsh was spoken among these hills. It needs emphasizing that the article refers only to this limited group; a similar survey among, for instance, 30 small dairy farmers in the Ludlow area might give a picture and lead to conclusions very different in several respects.

Owner-occupiers

The acreage of crops and grass of the 28 farms ranges from 21 to 87, with an average of 52. As in the mid-Wales Survey, most are owner-occupied; 23 being owned either by the farmer or a relative. Twenty of the farmers are married, one is a widower and the remainder are bachelors living with their mothers. No regular and little casual labour is employed on these farms, but 5 of the smaller farmers have some additional outside occupations and grown-up sons go out to work from 3 of the families. The 28 farmers have occupied the same small farms for periods ranging from 2 to 35 years and averaging 14 years. Twenty-three are the sons of local farmers and 4 of farm-workers; the other is a Lancashire coal-miner's son who married a local girl. The wives, indeed, are born and bred to this way of life as much as their husbands. The standard of formal education is not high, none of the farmers having gone beyond the elementary or primary stage. On leaving school, rather more than half went to work on their father's or other local farms; lorry driving and forestry were other previous occupations, and very few of them have travelled far beyond the local market town.

* "Scale of Enterprise in Farming." H.M.S.O.

The Farmhouses

All except one of the farmhouses are built of local stone. The most recent was erected during the first world war; 4 appear to have been built about 80 years ago and the remainder are considerably older; a few still having antique fireplaces open to the sky. Ground floors are normally of stone, some of the flags being deeply worn and some cemented over. One occasionally finds tiled floors and among these 28 farms there are two instances of boarded floors at ground level. Only 6 are connected to the main electricity supply, although an extension of this supply is now planned, and 14 use Calor gas for cooking. All but 4 have earth closets and only one has a bathroom. It is clear that most of the houses need extensive and costly improvements if they are to reach accepted modern standards. However, only one family has so far made use of the full House Improvement Grant available through the Rural District Council, and it may be significant that both the father and one son go out from this house to full-time employment.

Some of these farmhouses are difficult to reach, 7 of them being between $\frac{1}{2}$ and $\frac{1}{4}$ of a mile from the nearest tarred road, and 5 more over 100 yards away. However, access is not a problem for the majority, since many by-roads have been tarred in recent years, latterly with assistance under the Agricultural (Improvement of Roads) Act, 1955. Moreover, 18 have vans and 5 have saloon cars, and the other 5 can use tractors to go short journeys. Six of them have telephones and others use the local call-box or a neighbour's 'phone. The nearest shops are often 5 or 6 miles away, but tradesmen nowadays call at most of these farms and they are not so isolated as they were 20 years ago.

Their Way of Life

They produce a substantial proportion of their food on the farm. They normally have milk from one of their cows for most of the year, keep some laying hens and grow their own potatoes and swedes. Ten of them still kill a pig and cure their own bacon, but this practice appears to be dying out.

Is it a healthy life? Asked if they had been off work with illness during the last 12 months, 23 replied, "No". Asked if they could remember any previous illness, 10 farmers mentioned various ailments, 3 being the result of strains or fractures. Almost all agreed that theirs was a healthy life and their record appears to confirm this opinion.

HOLIDAYS ARE RARE

Asked when they last had a holiday away from home, most of these farmers and their wives responded with a wry smile. Only 1 of the 28 regularly takes one week's holiday per annum. Four others have been away for a few days within the past 5 years, but most have not spent a night off the farm since they started farming, or went on their honeymoon. However, they all go to their local stock markets, usually either weekly or fortnightly, and to occasional local farm sales. Every farmer has a sound radio and almost all read the weekly *Wellington Journal;*

but only 2 take daily newspapers and, so far, only 5 have television sets. Several families take one of the national farming weekly magazines and/or a Sunday newspaper and 5 borrow books from the Shropshire County Council travelling library. With few exceptions one is left with the impression of a community absorbed in farming and with little time for outside interests.

Their Families

Fifty-eight children born to 22 of these families are still alive—31 girls and 27 boys, 7 of them being below school age, 28 still at school and 23 having left. Of the girls who have left school, 6 were trained as nurses, 2 becoming state registered; 2 are in domestic service and 1 a shorthand typist; 5, including 2 of the trained nurses, are married. Of the boys who have left school 7 work on farms, 3 of them at home, and 2 are themselves small farmers, 1 is in forestry and the other on the railway. Of the children at school 11 are at Primary, 11 at Secondary Modern and 6 at Grammar Schools, indicating as good a proportion of clever children as could be expected anywhere. For their secondary education most of the children travel up to a dozen miles or more by school bus and car to Knighton (Modern), Presteign (Grammar) or Bishop's Castle (Bilateral). A few of the girls are making good use of their opportunities and one is to go to a university this year. But it is very common for children to leave modern and grammar schools at the minimum school-leaving age, and the boys in particular seem to be brought home as soon as possible to help with the work. Day release farm classes were organized last winter for the first time in this area by the Shropshire Education Committee at Bishop's Castle, but no small farmer's son has yet attended.

Wider Sociological Issues and Advisory Work

Why should the N.A.A.S. concern itself with the way of life on these small farms? The answer is that we are being forced to stand back and consider the wider sociological issues in the small farm problem, because we find a strict limit to the improvements which can be introduced quickly on these holdings through the Small Farmer Scheme. The crops and grass are normally already well farmed and the average stocking rate at the start of their schemes on all these 28 farms is very slightly under 2 forage acres per grazing livestock unit. Lime, slag, and farmyard manure are regularly used. There is still a little rough grazing (a total of 113 acres on the 28 holdings), but much of this is on slopes too difficult to include in improvement plans. The farm buildings are usually old (except for several modern small poultry houses and dutch barns) and suited only to the universally followed system of cattle rearing—single suckling with a few additional bought calves put on the milkier cows. All but one of these farms have flocks of 60 or more laying hens, averaging about 200 head, but very few pigs are kept and then, with one or two exceptions, only for the house.

Estimate of Income

A hypothetical 50-acre farm will serve to indicate the financial income which may be aimed at. Assuming an average selling price for stock of £8 per live hundredweight—a factor which admittedly applies only indirectly to a rearing farm—the annual gross sales from sheep and cattle are probably limited to about £1,100, without subsidies, after the grazing and forage crops have been well grown and utilized. A further £100 of net income is possible from 200 poultry. When all costs of machinery, rent or equivalent, fertilizer, seed, feed, and sundries are deducted, the net farm income would be small. However, with the help of his subsidies (£100 from the Hill Cow, £100 from the Calf and £50 from the Ploughing Subsidy) this farmer can achieve the way of life described above with the system to which he was born and bred.

Making Improvements

The District Advisory Officer, supported by grants available under the Small Farmer Scheme, now has the task of persuading these farmers to undertake an improved plan of farming. In fact, the grants payable to the 28 farmers included in this survey average £780 per farm over the 5-year period. The plans for the most part include useful reclamation of rough land and small drainage schemes on some farms, an accelerated programme of ploughing, cropping, and reseeding to improve grassland and a small increase in grazing stock. It has not been practicable to persuade these farmers to commit themselves to immediate short-term plans for major alterations in methods or management involving new skills, more risks, and perhaps greater capital.

The District Advisory Officer soon realized that, to quote J. M. A. Penders (1961), Inspector-General of the Netherlands Advisory Service, "Raising productivity in less developed areas is not solely a matter of improving production techniques in agriculture. All aspects of rural welfare . . . need to be taken carefully into account. So also must social and cultural aspects of rural life, conditioned as they are by tradition from the past".

The Stage is Set

In south-west Shropshire some of these aspects are already becoming more favourable. Better roads, motor transport, and educational facilities have come in the past few years; electricity and television will soon be available. These changes have come quickly—so quickly that one feels that it has not been appreciated that, in many respects, the stage has already been set in these hills for a revival in confidence and prosperity. What is required now is a comprehensive programme of education for change, not only in farming, but in home economy and outlook.

We have made a start in translating these ideas into practice. In conjunction with the Shropshire Education Committee, the N.A.A.S. has helped to run a series of evening meetings, held at two centres in the area, on a "Living from the Small Farm". These illustrated talks have dealt not only with farm management, as at the meetings in Cornwall described in the N.A.A.S. Quarterly Review, No. 48, but also with developments in farm and home economy on small farms. At these meetings we have talked over the facts revealed by our survey of these 28 farms and have shown small pilot farms in Sweden and pilot villages in the Netherlands for comparison. During last summer we staged a series of walks on small farms to show different methods of achieving the essential intensification of output and also illustrate improvements in housing and living conditions. On these walks we had the co-operation of the Agricultural Land Service in connection with improvements under the Livestock Rearing Act, and of the Surveyor of the local Rural District Council where improvements to the home have been made with the help of a House Improvement Grant. With the Shropshire Education Committee, we took a party of these farmers to visit the Farmer's Weekly farm at Broadley. To all these activities we make a point of inviting wives and families.

Accent on Home Economics

During this winter it is planned to hold further meetings with the accent on home economics, special attention being given to the use of electricity, the supply of which is now being extended to these parishes. The local District Officer of the Forestry Commission has agreed to talk at village meetings about prospects for local employment in forestry. Again looking to the future, there may well be a place for meetings on the subject of marketing and co-operation to achieve the advantages of scale. And we are making a particular effort in conjunction with the County Education Authority to attract school-leavers to attend day-release classes.

Contains First Steps

The Small Farmer Scheme business plans have been, for these farmers, no more than cautious first steps towards improving their income and way of life to a level which competes with the townsman's. The Scheme has, however, given the N.A.A.S. a golden opportunity to make friendly contact with this group and we have found them keenly appreciative of the interest which they feel is being taken in them, as well as of the financial assistance which the scheme offers. They, themselves, realize that there is no quick or easy solution to their problem through improved farming techniques or management, and are ready to understand the lessons of a factual survey of their economy and way of life as outlined in this article. There has been an outstanding response to invitations to the meetings and farm visits described above.

Need for a Broader Approach

Advisory Services in the past have fought shy of the wide implications of the family and community approach. However, we have to admit the limitations of the strictly technical agricultural and even of the economic approach to advisory work in an area such as that described above. Growing experience during the past few years in several Continental countries, the U.S.A., and now in our own N.A.A.S.-Nuffield Foundation pilot area in Devonshire, indicates some of the need for the broader approach which includes the home and the community. The experience described above seems to support one practical suggestion—that the N.A.A.S. can, within the limits imposed by available time and staff, improve its performance by active co-operation with other interested agencies working for rural development in an area such as these hilly parishes in south-west Shropshire.

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2. BOYER, R. S. Farm Management Group Meetings in Cornwall. *N.A.A.S. Quarterly Review*, 1960, No. 48.

Soil-borne Viruses

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NEGLECTED and unpopular for many years, the idea that plant viruses spread through the soil has recently received much publicity. Indeed, the flood of articles in the scientific and popular press has been such as to deter, without special commission, the composition of yet another on this topic, for there can be little new to say. The volume of published work reflects the speed at which research has progressed in this field and the interest it has aroused, but this should not distort assessment of its practical implications.

The discovery of new modes of virus transmission is always interesting, doubly so when it provides the key to long standing problems, but the problems are not thus suddenly endowed with an enhanced importance. And so it is with soil-borne virus diseases. The horticultural industry is not in imminent danger of collapse because of the discovery of soil-borne viruses in raspberry, strawberry, cherry, and many other crops. Unquestionably, the diseases they cause have been around for many years: the effects of some have probably become more obvious because of the relative freedom nowadays of commercial stocks of plants from infection by other kinds of viruses. Awareness of their nature and the problems they pose is an advance towards understanding how to control them.

The Viruses

Applied to viruses, the term "soil-borne" means viruses which have some underground method of spread that is independent of contact between the roots of infected and healthy plants. Quite possibly viruses may be transmitted through the soil by as many different means as they are above ground, but this article is concerned only with viruses that have ectoparasitic nematodes as vectors. So far, four such viruses have been found in Britain: they are arabis mosaic, raspberry ringspot, tomato black ring and tobacco rattle viruses. An account of how these were discovered is of some interest because it illustrates many of the features common to viruses of this kind.

Periodically since the 1920s, raspberries in eastern Scotland have suffered from a severe disease which stunts and kills plants of certain varieties. Outbreaks seemed to occur spontaneously, usually in the second year after planting, and to be restricted to patches in certain fields. The disease was first noticed in Baumforth's Seedling B about 1922; it recurred in Norfolk Giant in 1941, when it was noticed by Mr. N. H. Grubb in Angus and east Perthshire. The seriousness of some of the outbreaks prompted immediate investigation by Dr. R. V. Harris at East Malling Research Station, who named the disease "leaf curl" and showed that it was caused by virus.

Vital Clues

Because the disease seemed to spread in the field, an insect vector was suspected, but none could be found and it was not until 1953 that field and laboratory experiments yielded two vital clues. Leaf-curl infected plants were found to contain a virus that was sap-transmissible from raspberry to many kinds of herbaceous plants, including common weeds. Raspberry plants became infected with this virus only when their roots came in contact with soil from a disease outbreak. Subsequent experiments showed conclusively that this virus, raspberry ringspot virus, was soil-borne and that plants became infected through their roots.

These experiments revealed the existence in soils of another virus, named beet ringspot virus because of the conspicuous symptoms it caused in sugar beet. It also infected raspberry. The two viruses were unrelated, but often occurred together in soil from the same field. In 1954, Mr. F. A. Roach noticed outbreaks of a severe virus-like disease in Malling Exploit raspberry at Bere Ferrers, Devon, and from these infected plants a third sap-transmissible virus was isolated at Dundee and shown to be soil-borne. This was named raspberry yellow dwarf virus because of the symptoms it caused in raspberry and other herbaceous hosts.

Wide Host Range

It was soon found that all three viruses infected strawberry. Outbreaks of beet ringspot and raspberry ringspot viruses in strawberry were

discovered in many parts of Scotland, and in England outbreaks of raspberry yellow dwarf virus were found in localities ranging from Cheshire to South Devon and from Essex to Pembroke. The natural host range of these three viruses is quite astonishing for, apart from raspberry, strawberry, and sugar beet, they have been found infecting many other crop plants, such as cucumber, lettuce, oat, potato, rhubarb, tomato, and turnip and woody plants like cherry, peach, and grape vine, as well as many common weeds of cultivated land. The viruses also occur in continental Europe.

Problems in Naming Viruses

Because of their wide host ranges and geographical distribution it is not surprising that the viruses have been found and described before under different names, although their mode of transmission was unknown. Although there is no recognized system of classifying viruses, it is customary to give priority to the name which accompanies the first adequate description of the properties of a particular virus. The obligation is on the discoverers of "new" viruses to prove that their discoveries are unrelated to viruses previously described. Only thus can unnecessary duplication of virus names be avoided, although it may result in the use of inappropriate names for important viruses.

Two viruses are deemed related when each precipitates antiserum prepared to the other. This reaction is usually correlated with ability of the viruses to protect plants from infection by one another. Results from these kinds of tests showed that beet ringspot virus was a strain of tomato black ring virus described by Smith (1946) and that raspberry yellow dwarf virus was closely related to the arabis mosaic virus described by Smith and Markham (1944). It is almost certain that raspberry ringspot virus is a strain of the red currant ringspot virus isolated from Dutch material by Klesser (1951) but this cannot now be proved.

Many Properties in Common

All three of these viruses, arabis mosaic, raspberry ringspot, and tomato black ring, although unrelated to each other, possess many properties in common. All have polyhedral particles about 25–30 mμ diameter; thermal end-points in the range 55–70°C; wide natural and experimental host ranges and produce symptoms of the ringspot type in many of their hosts; they are soil-borne and are patchily though widely distributed in soils in Britain and continental Europe.

A fourth soil-borne virus, tobacco rattle virus, has been known for many years in Europe, where it causes stripe and curl disease in tobacco and stem-mottle disease in potato, but was not known in Britain before 1956 when it was found infecting potato in Scotland (Cadman and Harrison, 1959). Judging from the commonness of symptoms in potato crops—stem mottle in the haulms and spraing in the tubers—tobacco rattle virus must often occur in soils in Britain. The virus had in fact

been found before 1956 by Smith (1943), who called it belladonna mosaic virus. Like the three ringspot viruses, tobacco rattle virus has a wide host range: it has been transmitted experimentally to some 300 species and found naturally infecting some 100 others. Unlike the ringspot viruses it has rod-shaped particles of varying lengths and a thermal end-point of 75–80°C. There is no evidence yet of tobacco rattle virus causing serious diseases in fruit crops.

Transmission

The fact that these viruses occur in the soil and enter plants through their roots explained the apparent spontaneity of disease outbreaks in crops. The problem was then to discover how the viruses persisted in soils and were transmitted to plants. Glasshouse experiments showed that the viruses could not be eluted from infective soils nor could they be introduced into non-infective soils by watering these with infective plant sap or mixing them with infective plant debris. Some "receptive" kinds of non-infective soil could be made infective by growing virus-infected potato or sugar beet plants in them. The infectivity of soils was abolished by treatment with pentachloro-nitrobenzene (PCNB) or with tetramethylthiuram-disulphide (TMTDS) (chemicals which have no effect on the infectivity of the viruses *in vitro*) or by drying the soils for a week at room temperature.

Work in California

These and other results suggested that the viruses were associated with some kind of living organism in soil. The first clue as to its nature came from work in California where, in 1958, an ectoparasitic nematode, *Xiphinema index* Thorne, was shown to transmit the soil-borne fanleaf disease of grape vine (Hewitt, *et al.*, 1958). At that time fanleaf virus was thought not to be sap transmissible from infected grape vine, and there seemed no obvious connection between it and the soil-borne viruses discovered in Europe. Shortly afterwards, however, a closely related species, *X. diversicaudatum* Micol., was discovered in Britain (Goodey *et al.*, 1960) in association with outbreaks of arabis mosaic virus in various crops and quickly shown to be a vector of this virus (Jha and Posnette, 1959; Harrison and Cadman, 1959). It was later shown that grape vine fanleaf virus is in fact a strain of arabis mosaic virus (Cadman *et al.*, 1960). Last year, workers in Holland found a nematode vector, *Trichodorus pachydermus* Seinhorst, for tobacco rattle virus (Sol *et al.*, 1960), and just recently species of *Longidorus* have been shown to transmit tomato black ring virus (Harrison *et al.*, 1961). A nematode vector of Scottish strains of raspberry ringspot virus has just been found.

Closely Related Genera

All the nematode species listed in Table 1, which summarizes the published information to date, belong to rather closely related genera

and seem well fitted to transmit viruses, for they are equipped with long mouth spears with which they pierce the roots of plants. Experiments with the grape vine fanleaf and type strains of arabis mosaic virus have shown that single individuals of *Xiphinema* can transmit, and that the nematodes can acquire virus from infected plants and transmit it to healthy ones in 24 hr feeding periods.

Nematodes may retain the virus for 30 days or more without access to living plants, but there is no evidence that the virus passes through the eggs of infective nematodes (Raski and Hewitt, 1960; Jha and Posnette, 1961). Evidence of virus transmission by *Longidorus* spp. has been more difficult to obtain, largely because their greater sensitivity to environmental conditions has made reliable experimental techniques difficult to evolve. There is some evidence to suggest that larval forms transmit tomato black ring virus more efficiently than adults but there is no information yet on the relationships between virus and vector.

Control

GENETIC IMMUNITY

With crops that suffer severely from infection by these nematode-borne viruses, the simplest answer to the problem of control would be to use varieties which either resist infection by the viruses or are unpalatable hosts for the nematodes. Fortunately with raspberry, immunity from virus infection already exists among commercial varieties: although Malling Exploit, for example, is susceptible to infection by arabis mosaic, raspberry ringspot and tomato black ring viruses, Lloyd George is immune from all three, and other varieties possess immunity from one or more of the viruses.

As this immunity is simply inherited, there seem good prospects of producing new raspberry varieties which combine commercial usefulness with immunity from soil-borne virus infection. With strawberry, there is as yet no positive evidence of virus immunity but some to show that varieties differ in susceptibility to infection by different viruses even when, as is common with raspberry ringspot and tomato black ring, the viruses occur together in soils. In any event, genetic immunity is well worth searching for, particularly in longer-lived crops like cherry and grape vine, where soil-borne viruses cause relatively greater economic losses and where the prospects of successful control by other means are poor.

NEMATICIDES

Control by means of applying nematicides to soils is being tried at several centres in Britain, and these trials have already shown that applications of DD effectively decrease populations of *Xiphinema* and *Longidorus* in soils (Harrison *et al.*, 1961; Murant and Taylor, 1961). But it remains to be seen whether such treatments have any lasting effect on soil infectivity. The nematodes migrate in soils and may occur at depths greater than soil fumigants effectively penetrate; they seem

able to survive for long periods without access to living roots and, even if they become uninfective, sources of infection are usually present in the shape of infected weed plants.

All four of the nematode-borne viruses mentioned here pass into the seeds of infected plants of many common weeds and, when infected seeds germinate, they can give rise to apparently normal but virus-containing plants which serve as sources of infection (Lister, 1960). Thus, efficient control of weeds may be a useful complement to nematicidal treatments and may possibly be an easier and more effective way of decreasing the inoculum potential in soils.

Because the viruses infect so many different kinds of crop and weed plants, crop rotation of itself is of little avail as a means of decreasing sources of infection. But there is already evidence with *Xiphinema* and *Longidorus* that the nematodes prefer some kinds of plants to others, and a specific cropping sequence may well prove a means of effectively, if only temporarily, freeing land from infection. Experimental crop rotations seem worth trying but need coupling with studies on nematode populations and ecology.

Table 1

Nematode Vectors of Soil-borne Viruses

Virus	Nematode	Authority
Arabis mosaic		
Grape vine fanleaf strain	*Xiphinema index* Thorne	Hewitt *et al.* (1958)
Type strain	*X. diversicaudatum* Micol.	Jha and Posnette (1959); Harrison and Cadman (1959)
Tomato black ring		
Beet ringspot strain	*Longidorus elongatus* de Man	Harrison *et al.* (1961)
Lettuce ringspot strain	*L. attenvatus* Hooper	Harrison *et al.* (1961)
Tobacco rattle		
Dutch strain	*Trichodorus pachydermus* Seinhorst	Sol *et al.* (1960)
English strain	*T. primitivus* de Man	Harrison (1961)
German strain	*T. primitivus* de Man	Sänger (1961)

PROPAGATION OF STOCKS

The opening paragraph of this article probably puts soil-borne viruses in correct perspective so far as the fruit grower is concerned. To the would be propagator of healthy stocks, however, these viruses present a difficult problem. The most insidious feature of the nematode-borne viruses is that plants may quickly become infected with them but may not develop symptoms until the following growing season. For example, strawberry plants may be propagated on infected land and distributed in good faith as healthy, only to succumb to disease when planted

elsewhere, and valuable stocks of other kinds of plants may be ruined through the unwitting choice of infected land in which to propagate them. Examination of soil samples for the presence of nematodes seems the simplest way of forestalling such troubles but much more knowledge of the ecology, both of the nematodes and the viruses they transmit, is needed before the information from such surveys can be correctly interpreted.

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Fat in Poultry Rations

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FATS ARE the richest source of energy provided by animal or vegetable products. Weight for weight they supply 2·25 times as much energy as carbohydrates and proteins. Until comparatively recently, it was commonly believed that poultry had a low tolerance for fat. For this reason, for many years no consideration was given to using fat as a feed supplement, except in fattening rations to be fed for only a short time.

Efficiency of Poultry Diets

In recent years our knowledge of the nutritive requirements of poultry has increased rapidly, so that at the present time more is known about the nutrition of the chicken than of any other bird or animal with the possible exception of the laboratory rat.

AMINO ACIDS

Knowledge of the requirements for the essential amino acids has made it possible to formulate rations in which there is a careful balance of grains with animal and vegetable protein concentrates, so that the utilization of the protein of the rations is efficient. Since protein concentrates are among the more costly ingredients in any ration, it is desirable that the amounts used be kept to the minimum which will give optimum performance for the type of ration in question, i.e., whether it be for chick growth or for egg production. Utilization by the bird of excess protein for energy rather than for the formation of new tissue and maintenance of existing body tissue or for the formation of egg proteins is wasteful both nutritionally and economically.

VITAMINS

Studies of vitamin nutrition have also been responsible for overall improvements in poultry rations. With the availability of supplements of standardized vitamin content and of synthetic or purified forms of many of the vitamins, it is no longer usual for a deficiency of one or more vitamins to be a limiting factor in poultry rations. This is particularly true in the case of chick starting and broiler rations where deficiency syndromes and poor growth soon reflect any vitamin shortage.

Prior to the discovery of the vitamins now known to be required by the growing chick, vitamin deficiencies were no doubt common in chick rations. Certainly the experimental diets reported in the scientific literature were often deficient in one or more vitamins. As the importance of each of the vitamins came to be recognized and attention was paid in formulating rations to supplying the required amount of each of the

vitamins, the rate of growth expected of chicks gradually became more and more rapid. The alteration of chick rations in accord with expanding knowledge in nutrition has been a step-wise process. Thus, as long as a ration did not contain sufficient riboflavin, for example, growth was limited by the amount of that vitamin supplied, and no modification of the diet, unless directly or indirectly increasing the amount of riboflavin available to the chick, could stimulate growth. As, however, the vitamin requirements of the chick were met, it became evident that chicks grew faster if the protein level were increased beyond that considered optimal.

Energy Content

It was about at this point in the step-wise modification of chick starting rations that the production of broilers in the United States and Canada gained momentum. In 1947 investigators at the Connecticut Experiment Station published the now famous Connecticut broiler ration. This ration contained approximately 22 per cent protein and was, of course, well fortified with vitamins. In the Connecticut ration the level of fibre was kept to a minimum. The chick, for all practical purposes, may be considered incapable of digesting fibre and consequently any fibre in the diet is of no nutritive value.

In formulating this ration special consideration was given to the energy content. While investigators and practical poultrymen at the beginning of the century were aware of the importance of nutritive ratio, i.e., the ratio of protein to carbohydrate + fat × 2·25, the matter had received little attention to this time.

High Energy Rations

In the Connecticut ration the only grain component was ground yellow corn (maize). Corn contains approximately 2·5 per cent fibre as compared to wheat, which contains about 3 per cent, or coarse grains, such as oats and barley, which contain 5 per cent and 6 per cent fibre. Corn, furthermore, contains approximately 4 per cent fat which is a larger amount than is present in most other cereals. The net result of this low fibre and high fat content is that the metabolizable energy* content of corn is about 1,550 calories, while wheat, barley, and oats contain 1,380, 1,255, and 1,200 calories, respectively, of metabolizable energy per pound.

As a result of using corn as the only grain in the ration to the exclusion of cereals of lower fat content, the energy content of the Connecticut ration was above that of rations commonly used to that time, and the Connecticut ration was designated as a high-energy ration. Its calculated metabolizable energy content is approximately 1,420 calories per pound. Growth response to this ration as well as the efficiency of feed conversion were so favourable that industry was immediately interested in the

* Metabolizable energy is the combustible energy of the feed minus the excreted (fæcal and urinary) energy.

formulation of high energy rations. It was evident that, with the balance of vitamins and amino acids that could now be achieved, energy had become a limiting factor determining the results obtained with broiler rations.

Use of Fats Economically Possible

About 1950 a surplus of fats in the world market because of a decline in soap manufacture, following the advent of synthetic detergents, made the use of fats economically feasible. As a result intensive research was commenced to study the use of fats as supplements in poultry feeds.

The actual requirement of the chick for fat was found to be very low. Except through the use of synthetic diets, a deficiency of essential fatty acids is apparent only in chicks fed diets from which the fat has been extracted.

Contrary to previous assertions that chickens have a low tolerance for fat, it was found that chickens could utilize rations that contain as much as 40 per cent fat. What then of the earlier belief that chickens have a low tolerance for fat? It is possible to formulate rations which, when fed experimentally to chicks, will show a deleterious effect from supplementation with fat. For example, harmful effects may be demonstrated when fats are added to rations deficient in protein or in certain of the vitamins.

It now seems that earlier unfavourable reports regarding the feeding of fats to poultry were most likely due to the fact that the addition of fat to a ration already deficient in protein and/or vitamins aggravated the imbalance of nutrients in such a ration. The questions of the effects of dietary fat level upon protein and vitamin requirements have been the subjects of a great deal of research and some of the findings are extremely important in their practical applications in the formulation of poultry feeds. Likewise important, and also the subject of considerable investigation, are the extent to which fats are themselves utilized by poultry, the nutritive properties of fats of different types and of different quality, and the value of supplementary fat in rations for different classes of poultry.

Efficiency of Utilization and Melting Point

In general, poultry are able to utilize low melting point fats more efficiently than high melting point fats. For example, corn oil has a digestibility coefficient for the chick of 90–95 per cent, feed tallow 75–80 per cent and hydrogenated animal tallow less than 45 per cent. It should be noted that the coefficient of digestibility for any fat is not absolute but may be altered by such dietary factors as the levels at which it is fed and the protein content of the diet, as well as by the age of the birds.

The relationship of melting point to utilization of fats is not rigid and there may be considerable differences in utilization of fats of similar melting points. We have much to learn regarding the effects of different

proportions of saturated fatty acids and of their arrangement and distribution in the triglycerides making up different fats.

The metabolizable energy content of fats is usually considered to be about 3,200–3,900 calories per pound. Depending upon the particular fat and the dietary conditions under which it is fed, the metabolizable energy may vary somewhat. In this connection it may be observed that recent evidence, using very precise techniques for determining metabolizable energy, suggests that the values at present available for different feedstuffs should not be regarded as absolute.

Stability and Antioxidants

The stability of fats used in feeds is very important. As rancidity develops in a fat mixed into a feed certain of the vitamins, notably the fat-soluble vitamins A, D, and E, as well as some of the B-complex, may be destroyed. For this reason, as well as because of the unpalatability of rancid fats, most fats to be used as feed supplements are stabilized by the addition of an antioxidant. It is certain that some of the early unfavourable results obtained with high-fat rations were due to vitamin deficiencies resulting from the destruction of labile vitamins by rancid fat.

It should be noted that a high free-fatty-acid level in the fat may not necessarily lead to poor results from the feeding of the fat and that, in fact, fatty acids themselves may be fed to poultry without harmful effect. It should also be noted that the metabolizable energy of mixtures of fatty acids may be much lower than the neutral fats from which they are derived. Apparently free saturated fatty acids cannot be utilized to the same extent as the same fatty acids in glycerides.

Supplementary Fat in Relation to Requirements for Other Nutrients

Feed conversion may be improved in proportion to the increased energy content of the rations, provided the balance of all nutrients is maintained in proper ratio to the energy level. Improvement in feed conversion may be expected to reach a maximum beyond which the concentration of nutrients in the intestinal tract is greater than can be efficiently absorbed as the ingesta moves through the tract.

Since fats do not contribute any nutrients other than energy, care has to be taken in formulating rations to which fat is added. The substitution of fats for grains and grain by-products automatically reduces a number of valuable nutrients contained in these feedstuffs. Thus it becomes essential to replace the displaced nutrients with other sources.

BALANCE BETWEEN PROTEIN AND ENERGY LEVELS

In chick starters or in broiler rations the balance between protein level and energy level is of prime consideration in deciding whether or not fat supplementation of the ration will be beneficial. We are speaking here of nutritional benefits without taking into account the relative

costs of different feed ingredients. The latter will vary from time to time and have to be calculated from prices prevailing at the time. As already stated, if the ratio of protein to energy is too high, protein will be utilized to provide energy for the body metabolism. If, on the other hand, the ratio of protein to energy is too low there will not be sufficient protein to permit the maximum rate of growth of the bird. This is true with either growing chickens or turkey poults. The efficiency with which the protein itself is utilized will be high, but, because of the slow rate of growth on a sub-optimal level of protein, the efficiency with which the ration as a whole is utilized will be low. Generally speaking, a rapid rate of growth and a high efficiency of feed utilization go hand in hand. In rations in which the energy level is raised by the addition of fat, the level of protein which may be used efficiently is higher than in rations of lower energy content.

LYSINE AND METHIONINE

In addition to the role of the total amount of protein in determining whether or not fat may be advantageously used as a feed supplement, levels of the individual amino acids present are also important. There do not seem to be exact data available concerning the optimum percentages of the various essential amino acids in the total protein content of rations supplemented with fat. An increased requirement for lysine in rations supplemented with fat has been reported and the data of numerous experiments emphasize the importance of methionine in chick diets containing high levels of fat.

Except in cases where the calorie–protein ratio in the diet is far from adequate, growth rate will not be so consistently affected by the level of energy in the diet as the efficiency with which the feed is utilized.

Vitamin Levels adjusted to Calories in Ration

Particular care has to be taken to ensure that the vitamin content is adequate in rations that are to be supplemented with fat. With good quality fats that have been properly stabilized with antioxidants, there is little danger that the rate of vitamin destruction from oxidation will be increased by the presence of the fat. On the contrary it has been shown with vitamin A that the antioxidants in added fat will improve the stability of that vitamin in the ration. However, because of the increased efficiency of feed utilization of fat-supplemented rations, the intake of vitamins is proportionately reduced. As with protein, the level of vitamins supplied should possibly be related to caloric content of the ration rather than to the weight of the ration as is current practice. The choline requirement of the chick appears to be increased when high levels of fat are added to a diet low in methionine. This increase in choline requirement appears to be secondary to an increased need for methionine. Folic acid may be a limiting factor in rations of high protein and fat content. At sub-optimal levels of folic acid, growth may be depressed by increasing the levels of protein and fat.

CALCIUM EXCRETION

The relationship between dietary calcium and fat levels on the proportions of calcium and fat excreted has been the subject of a number of investigations. Availability of both calcium and fat may be reduced if appreciable amounts of unabsorbable calcium soaps are formed and excreted. All fats are not alike in their effect on calcium excretion. The more saturated fatty acids have a greater tendency to be excreted as calcium soaps, and in a ration marginal or sub-optimal in calcium the amount of calcium excreted in this way may be sufficient to depress growth and bone calcification.

Fats as Supplements to Laying Rations

Although most of the experimental studies on the feeding of fat to poultry have been conducted with growing birds, there has been some interest in the use of fats as supplements in laying rations. The addition of fat to laying rations at a level of 2–3 per cent improves the physical characteristics of the mash, dustiness is reduced and there is less wastage of feed. There has, however, been some concern that the addition of fat to the rations fed to laying birds will result in over-fat birds and that mortality may be increased. Data indicating such to be the case have shown that heavy breeds are more apt to be subject to ill effects leading to increased mortality than are the light breeds.

Controlled experiments in which laying birds kept in cages have been fed supplementary fat at levels as high as 10 per cent, which is beyond what would normally be considered practicable, has little harmful effect in itself, even when fed over a prolonged period of time. However, if the level of energy in the rations is increased commensurate with the level of fat added, adverse effects may be expected as a result of the high energy intake of the hens.

It has been suggested that the fat content of the laying diet may affect egg quality. In this regard it has been reported that the inclusion of 3 per cent of feed-grade tallow in the diet of hens did not affect the flavour of eggs, either fresh or after storage. Off-flavours may, of course, be expected to result if more than about 1 or 2 per cent of a fish oil is included in the laying ration.

Summary

The question of whether or not to use supplementary fat in poultry rations is probably largely one of availability and cost. The requirements for essential fatty acids is extremely low and will be met by the fat content of the natural ingredients present in the ration. There is some advantage in increasing the fat content of the ration, beyond that resulting from the fat content of the ingredients, in improved texture and reduction of wastage. The addition of fat to rations to increase the energy content of a ration will, provided the balance of the other nutrients is favourable, increase the efficiency with which the ration as a whole is utilized, i.e., the number of pounds of feed required to produce

a pound of meat or a dozen eggs. Depending upon the cost of energy from fat supplements as compared with that provided by grains, it may be desirable to include fat in the diet. Then, too, if the higher fibre grains are cheaper than corn and if fat is available at a reasonable price, it may be advantageous to raise the energy content of the high fibre–low energy grains with fat to achieve the same performance from the rations.

New Methods for Milk Advisory Work

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ONE OF the main concerns of the Advisory Officer must be to assess how effective is the advice which has been given. If, on analysis, it is disclosed that the advice offered is seldom accepted, then an attempt must be made to find out which elements, if any, are affecting the results.

It is suggested that the following are the main considerations:

1. was the advice sound?
2. did it have a monetary appeal?
3. was it put over in understandable form and/or language?
4. was it offered at the psychological moment and in the right manner?

The N.A.A.S. Milk Advisory Officers have applied three experimental techniques, all designed to get over to the dairy farmer the latest research work completed by the National Institute for Research in Dairying, on the subject of measuring performance in machine milking, i.e., the number of cows milked per man hour.

The advice offered was based on original research work carried out over a long period and this is the first time that positive standards have been provided with which to compare the results obtained in milking plants on farms. Never since the days of the Petersen films (from the University of Minnesota) have dairy farmers been made to think so positively whether or not their own systems were good or wasteful of labour.

The standards given made it quite clear that a herd of at least fifty cows, i.e., with forty-five or so in milk, can now be considered a one man unit, and experience has shown that, given the right equipment with the right number of units, it is comparatively easy to milk twenty-five to thirty cows per man hour.

Since economists now tell us that 20 per cent of the cost of milk production is in the labour used in the management of the cows,* it is obvious that methods of reducing labour at milking time, easier methods of feeding bulk foods, the storage of litter and fodder at easily accessible points, and direct methods of manure and slurry handling can make great savings.

* Calculated from data on p. 15 of "Cost and Efficiency in Milk Production", MAFF, 1960.

In the three techniques under review a serious attempt was made to present the research data in interesting form and, since figures pertaining to the farmers' own achievements were used, the exercises were realistic and stimulated the farmers' interest in attempting to get better results with their milking plant.

The release of so much important research data in 1958 fortunately coincided with a marked increase in the number of farmers about to alter their systems of management for the dairy herd, and many have been readily receptive of advice based on this work.

In all these exercises the criteria for success must be, will these suggestions help to cut the cost of production by reducing labour costs and, since 60 per cent of the cost of milk production is in the food used, will the system ensure the more accurate feeding, particularly of the expensive concentrate ration?

THE CARD SYSTEM

"*To compare the performance achieved on any dairy farm with the standards provided.*"

A series of lectures was organized to explain the importance of the "right number of men" using the "right number of machines" on a herd of "known average yield".

Explanation was made at the meetings that cards, asking five vital questions, would be available as members of the audience left the hall; distribution of the cards was therefore voluntary.

It was emphasized that the information supplied would be treated as confidential.

SPECIMEN CARD

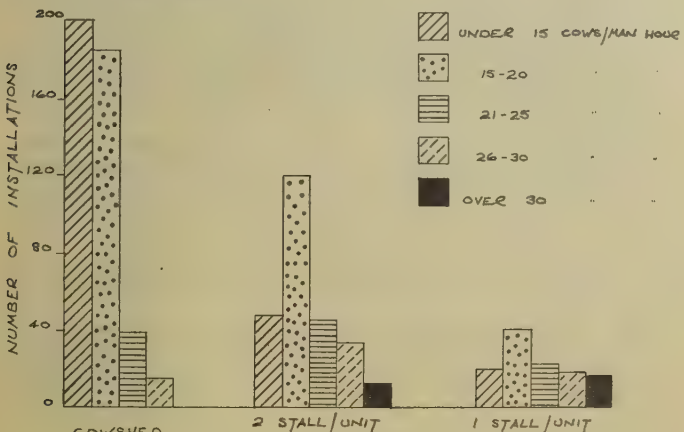
MINISTRY OF AGRICULTURE, FISHERIES AND FOOD
NATIONAL AGRICULTURAL ADVISORY SERVICE

THE MORNING MILKING OF..... 1960
No. of cows milked.....
No. of gallons produced (a.m.).....
No. of men employed whole and part time (e.g. 1½).....
No. of milking machine units.....
Time first cluster put on..... a.m.
Time last cluster taken off..... a.m.
MILKING PREMISES
Cowshed (Single or double range).....
Parlour (State type and number of stalls).....
.....
Name and address .....
.....
.....

As soon as these cards were returned the necessary calculations were made and a pro-forma letter covering all the points which might be involved was completed, comparing *actual* with *possible* performance. Certain sections applicable to the case were specially marked for the farmer's attention.

A second performance card was enclosed with the letter and the suggestion made that, as soon as the advice was implemented, the second performance card should be returned. Only when some special factor appeared to complicate the case was a visit to the farm necessary.

Last winter over 800 farmers took advantage of this method of checking on their own standards of efficiency. An analysis of the returns is given on the chart below.



Performance of all installations in cows/man hour.

Further analysis of the performance cards returned showed that:

1. *in cowsheds* 14 per cent had too many men and 15 per cent too many units/man;
2. *in* 2 *stall/unit parlours* 8 per cent used too many men and 6·7 per cent had too many units/man;
3. *in* 1 *stall/unit parlours* 10 per cent had too many men and 21 per cent too many units per man.

Here then was a direct challenge to the farmers to tackle the deficiencies in their milking machine management.

This is considered to be a good example of the group approach to advisory work.

A NEW TYPE OF SHOW EXHIBIT

"*Choosing and Using a Milking Parlour*"

This exhibit was a departure from the usual and acknowledgment must be made to Dr. Dodd of N.I.R.D., who assisted materially in its design. The exhibit itself was *not* designed to give specific information on its panels.

It was divided into two parts. One showed an outline of every type of milking parlour, grouped according to whether they were one or other of the two basic types, i.e., one unit to one stall or one unit to two stalls, and whether for one or two men operation. Each outline was lighted from the rear. The whole success of the exhibit depended on individual farmers supplying *detailed and accurate information about their own farms.* A punched card selection system eliminated the light from behind the parlours inappropriate to the case under discussion and, after considering (1) the number of cows in the herd, (2) the average yield, (3) whether for one or two men operation and (4) the level of concentrate feed, *the only suitable parlours for the conditions on that farm* were still illuminated. A discussion then followed on the special features of the parlours selected; with some details concerning costs of appropriate equipment.

The other half of the exhibit with its calculating dial again used information provided by the farmer. *It was possible to compare what he was actually doing with the accepted good standard of performance.*

Producers have proved themselves particularly interested. There has been no reluctance to produce detailed figures relating to their own farms and advice can be given for immediate implementation on the farm. A large number of clients can be dealt with in a short space of time.

The most pleasing reaction has been the intense interest taken in this new type of exhibit which deals with the farmer's own particular case.

Both of the techniques detailed above will continue to be widely used in day to day advice.

CLOSED CIRCUIT TELEVISION

This technique has been applied on two occasions only, and its main object is to make the camera, which is of necessity sited in a restricted area, throw a picture on to screens, which can be seen by a large number of people.

One of the problems of the newer types of tandem or herringbone milking parlours is the inability to allow a reasonable number of people to see milking in progress.

Thus, with television screens facing outwards and arranged in circular form in the centre of a barn or other building, with seats of straw bails arranged suitably, the method has proved a limited success. The one drawback is that sometimes the camera itself cannot be easily placed to show, for example, the complete milking cycle and the operations in the dairy.

Obviously, two cameras are required and the commentators need considerable rehearsal. The cost is high at present but it is fair to assume that it could be widely used in future.

Because of the high standard of production on "commercial" television it is obvious that any efforts by advisory officers must be most carefully planned.

In all advisory work one must use every form of appeal and every conceivable method to evoke and hold interest, if one is to succeed in getting over basic technical information. The job is not made any easier as the result of good television programmes and sound broadcasts which compete strongly for the limited time which most farmers allow themselves for acquiring further knowledge.

Experiments on Dairy Cow Feeding and Milk Composition

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A SERIES of experiments has been carried out in recent years with the dairy herd at Wye College to study the value of silage and hay in winter feeding and the effects of feeding and disease on the chemical composition of milk.

Value of Good Bulk Feeds

The importance of quality in terms of digestibility and energy content in the dry matter, in influencing the contribution which hay and silage can make, has been demonstrated. The value of good bulk feeds was shown by an experiment in which they were fed to supply the requirements of autumn calved cows for (a) maintenance and the production of one gallon of milk, or (b) maintenance and the production of three gallons during the period January to March. The average lactation yields for the cows which had been on the two treatments were (a) 1,063 gallons at 3·86 per cent butterfat in 301 days and (b) 1,097 gallons at 3·82 per cent butterfat in 293 days.

Steaming-up

Work has been done on the steaming-up of cows (as opposed to heifers which may differ from them physiologically). The results of this have shown that, whilst with low grade fodders the practice of steaming-up with concentrates has an appreciable effect on milk yield, little benefit results from such steaming-up when high quality fodders such as good autumn grazing, kale and good silage and hay are fed in adequate amounts. The latter conclusions are illustrated by the data from two experiments summarized in Table 1 in which cows were fed high quality bulk feeds before calving.

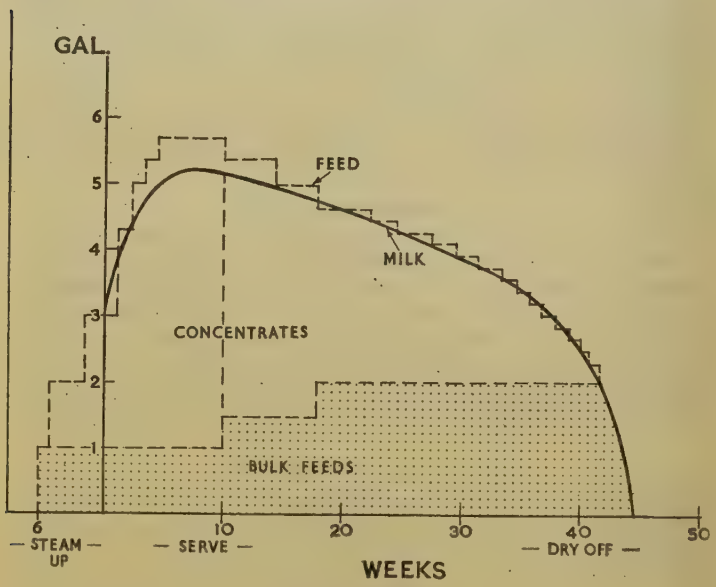
Scheme of Feeding

On the basis of these and other investigations, the scheme of feeding illustrated diagrammatically in Fig. 1 has been suggested. *Depending on the quality of the bulk feeds available*, they are expected to make a contribution before calving and in the early part of lactation *ranging* from maintenance only, to maintenance and the daily production of

two gallons of milk or its equivalent in steaming-up. The provision of limited amounts of concentrates before calving is probably advisable in most instances to accustom the cow to the feed, but this should seldom exceed 84 lb. In the early part of the lactation, concentrate feeding should exceed immediate production requirements so that a high peak yield is stimulated. After the tenth week of lactation, however, when the risk of wasteful concentrate feeding arises, an increasing contribution

Table 1
Yield and Composition of Milk from Autumn-Calved Cows

	1957–58		1958–59	
	—	Steamed up	—	Steamed up
Concentrates fed before calving (lb/cow)	—	190	—	220
70-day milk yield (gal)	352	395	326	319
305-day milk yield (gal)	1088	1117	1042	983
Butterfat in early lactation (per cent)	3·99	4·08	3·98	4·20
Solids-not-fat in early lactation (per cent)	8·50	8·62	8·52	8·55



A scheme of feeding

from bulk feeds is expected. The amount of concentrates fed in this declining phase of the lactation is reduced as yield falls away and the cow is eventually dried-off. An alternative economy in this phase can be made by using a less concentrated production mixture, possibly home-mixed, which is less expensive. For example, a "3½ lb to the gallon cake" could be replaced by one which has to be fed at 4–4½ lb to the gallon.

Milk Composition

The effects of feeding on milk composition are summarized in Table 2. The influence of starch equivalent intake on solids-not-fat levels is well illustrated with a steady increase in the protein content as the level of starch equivalent is increased.

Table 2
The Effect of Feeding on Milk Composition

Starch equivalent level of feeding as per cent of Woodman's standards	Butterfat per cent	Solids-not-fat per cent	Lactose per cent	Protein per cent
87	4·01	8·42	4·52	2·96
97	4·14	8·55	4·52	3·07
113	3·95	8·63	4·50	3·11
125	4·10	8·71	4·52	3·21

These results were obtained in a Latin Square type of experiment and such results are not always substantiated in long term experiments or in the field. Data have been accumulated which show that subclinical mastitis can influence milk composition appreciably and may counteract the beneficial effect of better feeding. High cell counts were found to be associated with the incidence of subclinical mastitis (haemolytic staphylococci) and relationships have been calculated between cell count and milk composition.

Table 3 summarizes the effects on chemical composition of the high cell counts associated with staphylococcal mastitis. These show that the lactose fraction of the solids-not-fat is mainly affected, with a marked depression occurring as the level of infection increases.

Table 3
The Effect of Mastitis on Solids not Fat Levels

	Cells/ml (thousands)	Solids-not-fat per cent	Lactose per cent	Protein per cent
Low infection	100	8·94	4·91	3·15
Medium infection	500	8·65	4·70	3·06
High infection	1000	8·50	4·60	3·02

Further details are available in Holmes, Arnold and Provan (1960), *J. Dairy Res.* **27**, 191–204, and in the Guides to the Department of Agriculture and College Farm, Wye College, 1960 and 1961.

Frequency of Irrigation Need for Potato Crops

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THE MINISTRY of Agriculture's Technical Bulletin No. 4: *The Calculation of Irrigation Need*, was first published in 1954, and it is a source of satisfaction that the ideas and figures contained in that bulletin have stood the test of time. Subsequent experience and experiment have, however, indicated that some modifications in relation to specific crops are now advisable. In particular the map showing the frequency of irrigation need contained in that publication, although still remaining a good general guide to the problem, is an underestimate for some crops and an overestimate for others.

As might be expected, the underestimation is most serious for shallow-rooted crops. These crops are those which suffer most from temporary shortages of soil moisture and which respond best to controlled irrigation, both in regard to increase of yield and financial return. The old idea of a frequency of irrigation need of 9 years in 10 in the south-east and only 5 years in 10 in the north and west is therefore, in the light of modern knowledge, dangerously misleading. In the nominally "wetter areas", although the amounts of extra water needed are not so great as in the south-east, the frequency of need is such that irrigation for certain crops demands serious consideration.

Supplies More Easily Available

In previous reviews of the future of irrigation it has always been assumed that the need for water is most urgent where the potential supply is least. Although this conclusion remains substantially true, it now appears that there is also a frequent need for water for irrigation use in areas where supplies are more easily available. If the economics of irrigation demands water at low cost, then it is a reasonable hypothesis that water should be used in those areas where supplies are still adequate if the need for such water can be proved.

The present paper deals with the irrigation needs of the potato crop, and indicates the national demand for extra water to ensure maximum production. Its findings therefore prompt two questions which are important both to farmers and advisers. Is irrigation an economic proposition in areas to the north and west? If so, what steps should be taken to ensure adequate supplies of water for this purpose?

New Potatoes

Trials have shown that new potatoes respond well to controlled irrigation and that the recommended treatment is to maintain a $\frac{1}{2}$ in. soil moisture deficit during the months of May and June. With this specification, it is possible to use the methods outlined in the Technical Bulletin to discover the frequency and amount of irrigation need.

Example 1. The average annual rainfall of inland stations in west

Lancashire, such as Hutton, or Fairfield Experimental Horticulture Station, is about 37 in. For the two months May and June the average is about 5 in. Using Table 8 of the Bulletin, we can assume that the total of the May–June rainfall in a sample period of 10 years will range from 8·7 in. in the wettest year to 1·95 in. in the driest. The average potential transpiration for this two-month period is 6·75 in. in this area, so that irrigation would theoretically be needed, when the rainfall does not exceed 6·25 in., to maintain the required 0·5 in. deficit. According to the calculated samples this would occur 8 years in 10, and during these 8 years a total of 15·90 in. of irrigation would be needed.

This sampling method has obvious defects. There can be no guarantee that any 10 actual years will fit the sample very closely. The wettest year still counting as a "year of need" will theoretically demand so little extra water that, in practice, no irrigation would have been applied. On the other hand, the use of two-month totals excludes the years when the first month was dry (and irrigation needed) and the second month had ample rainfall. In practice, the results of this sampling method seem to be reliable. If the actual records of rainfall and potential transpiration in this area for the years 1950–59 are examined and each month considered separately, it is found that irrigation to this specification of $\frac{1}{2}$ in. planned soil moisture deficit would have taken place 8 years in this decade and a total of 16·6 in. applied.

Example 2. The south-west of England is popularly regarded as wet, but it is not generally realized that a large proportion of the rain there falls during the winter. At Penzance, with an annual average of 41·5 in. the average during May and June is only 4·4 in. The average potential transpiration for these two months is 6·6 in.

The sampling method gives a frequency of 8 years in 10 using a total of 18·75 in. during those 8 years. A check on the actual records for 1950–59 shows that irrigation would have been used 7 years during that period with a total of 18·3 in.

Need in England

With frequencies as high as 8 years in 10 in the west and north-west it is not surprising that the need over the country as a whole is larger than might have been deduced from the original "frequency of irrigation need" map prepared almost 10 years ago. The frequency of need for new potatoes in England is shown in Fig. 1. Fig. 2 shows the average amounts of irrigation water needed during irrigation years. The amount needed during the driest year in 10 is approximately double this average amount.

Fig. 1 shows four areas with a theoretical frequency of 10 years in 10. This cannot mean that the May–June rainfall never exceeds the potential transpiration less $\frac{1}{2}$ in., but that it is unlikely to occur more than once every 20 years. The general figure for England is 9 years in 10 and few lowland farms or holdings would have a frequency of less than 7 years in 10.

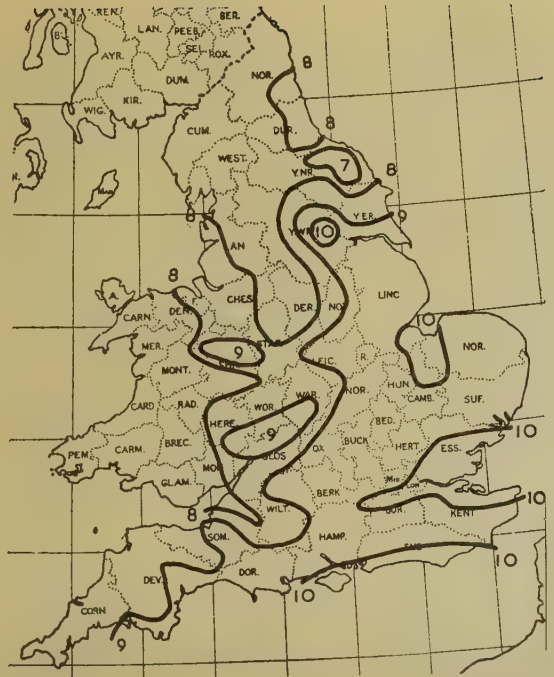

FIG. 1. The frequency of irrigation need for new potatoes during May and June (expressed as the number of years in 10).

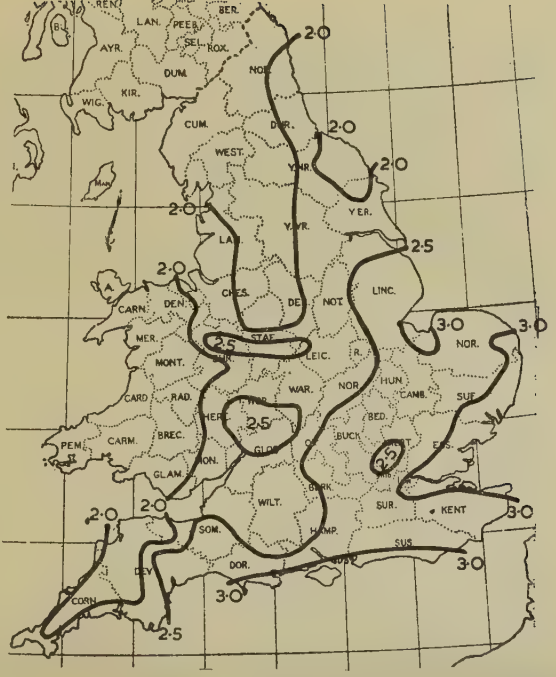

FIG. 2. *New Potatoes:* average amount of water required in the years when irrigation is needed in May and June.

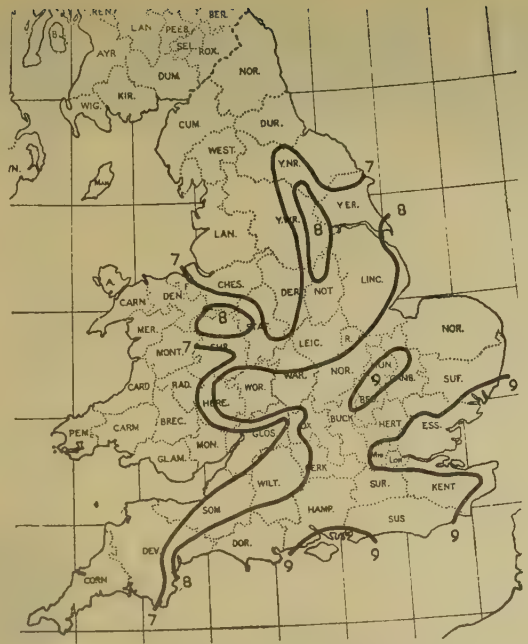

FIG. 3. The frequency of irrigation need for maincrop potatoes during July and August (expressed as the number of years in 10).

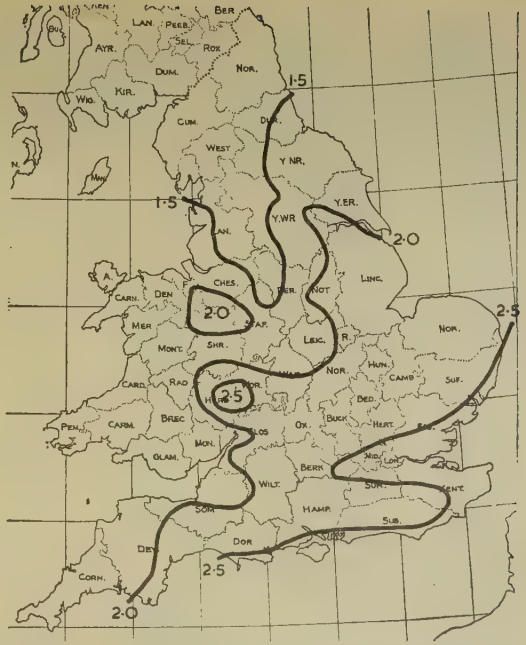

FIG. 4. *Maincrop Potatoes:* average amount of water required in the years when irrigation is needed in July and August.

Fig. 2 suggests that the average irrigation need is about 2½ in. but an allowance could be made for the possibility that the last irrigation application of, say, ½ in., which would theoretically be needed just before lifting, might not in fact be applied.

Table 1
Frequency of Irrigation Need for New Potatoes in Wales
(Years in 10)

County	Average annual rainfall (in.)					
	30	33	36	39	42	45
Anglesey	—	—	8	8	—	—
Brecon	—	—	8	8	7	7
Cardigan	—	—	8	8	7	6
Caernarvon	—	—	8	8	7	6
Carmarthen	—	—	—	8	7	7
Denbigh	9	8	8	7	6	—
Flint	8	7	7	—	—	—
Glamorgan	—	—	9	8	8	7
Merioneth	—	—	—	8	7	7
Monmouth	9	9	8	7	6	6
Montgomery	9	9	8	8	7	6
Pembroke	—	—	8	8	7	7
Radnor	—	—	8	8	7	6

Table 2
Total Amounts of Irrigation needed for New Potatoes in a 10-Year Period

County	Average annual rainfall (in.)					
	30	33	36	39	42	45
Anglesey	—	—	19·7	16·5	—	—
Brecon	—	—	19·4	16·5	14·3	12·5
Cardigan	—	—	16·2	13·8	12·0	10·1
Caernarvon	—	—	18·2	15·7	13·8	11·7
Carmarthen	—	—	—	15·8	13·8	11·9
Denbigh	21·1	17·9	15·2	12·9	11·0	—
Flint	16·5	14·0	11·7	—	—	—
Glamorgan	—	—	21·5	18·8	16·6	14·5
Merioneth	—	—	—	17·0	14·6	12·7
Monmouth	22·8	19·7	16·4	14·2	12·1	10·0
Montgomery	23·0	20·0	17·2	14·4	—	—
Pembroke	—	—	18·4	15·8	13·7	12·0
Radnor	—	—	17·2	14·6	12·8	9·0

Need in Wales

Because of the rapid increase of rainfall amounts with height above sea level, it is difficult to give a clear picture of the need for irrigation on new potatoes in Wales by means of a map. Tables 1 and 2 give the calculated results.

Maincrop Potatoes

Experience has suggested that the best results per inch of water applied to main crops are obtained by maintaining a ½ in. soil moisture deficit during July and August, the period during which the potatoes are "bulking".

The sampling method can now be applied to this specification and the results are illustrated by Fig. 3, the frequency of irrigation need. Fig. 4 shows the average amounts of water required during years of irrigation. These maps indicate that the general frequency in England is about 8 years in 10 and the average amounts about 2 in. during these years. Again in dry years, about double this amount could be used with advantage.

Potato Blight

Fears have been expressed that irrigation would increase the risk of losses due to potato blight. In regard to new potatoes the night temperatures in May are often too low to permit the disease to develop, and an attack in June would be unlikely to build up quickly enough to impair growth of the tubers.

In the case of maincrop potatoes, irrigation is confined to July and August. It is possible, but not proven in practice, that this would increase the incidence of blight; but comparison of the increased rates of bulking due to irrigation with the decreased rates due to disease show that the potential gain is greater than the potential loss, and that the loss can be appreciably reduced by modern spraying techniques and timing.

Conclusions

Accepting the hypothesis that planned soil moisture deficits of ½ in. are desirable at certain periods during the life of the crop, the frequency of irrigation need for new and maincrop potatoes is very high over most of England and in the drier parts of Wales. Experience has shown that the increases in yield can be considerable.

Perhaps the major advantage to be gained from increased irrigation of potatoes on a national scale would be the stabilization of national yields, quite apart from the increased financial return to individual farms. Interpreting the "need" for irrigation as the requirement for maximum yield, it seems certain that the frequency of need for potatoes is far greater than has hitherto been generally realized.

Wire and Slatted Floors for Housing Poultry

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WIRE AND slatted floors have been widely used in range shelters, colony houses, and night arks since the early 1930's, but it is only in recent years that poultry have been housed intensively in large numbers on this type of flooring. The structure allows a free circulation of air, and

birds are unable to come into contact with accumulated droppings which are a potential source of infection. Both these factors contribute towards making a high stocking rate possible.

Since the war, intensive methods have taken over almost completely from the conventional range system. Yards, deep litter and batteries have enabled the farmer to keep more birds on less ground. The most intensive of these systems is the battery unit, but here the limiting factors are high capital outlay per bird, high depreciation and a heavy demand on labour. Any new system therefore had to be designed to overcome these limitations. Poultry farmers began to experiment by putting large droppings pits in deep litter houses and it was found that birds spent a great deal of time on the pit slats or wires without any apparent discomfort. These early trials led to the now popular all-wire or slatted floor house.

Construction of House

A windowless house is normally used as this has a number of advantages over the conventional house. Single glazed windows present a weak point in the insulation of a house and are a source of draughts. Also with a windowless house, there is no danger of disturbance caused by movement outside. The absence of natural daylight permits the use of artificial light patterns, and this seems essential with some strains, if high losses from prolapse are to be avoided.

Walls should be constructed of concrete blocks up to the level of the wire or slatted floor, because of the high moisture content of the accumulated droppings. At this level a damp proof course is put in, and then up to eaves-height the structure may be of wood or hollow insulating block. The roof should be insulated to give a "U" value of below 0·2. A wide variety of insulating materials are available including glass wool, insulation board and expanded polystyrene. It is important that the underside of the insulating material is vapour sealed so that moisture does not penetrate.

FLOOR SECTIONS

The floor of the house should be constructed $2\frac{3}{4}$–3 ft above ground level, the floor sections being supported by 5 in. × 3 in. bearers placed on uprights. Floor sections usually measure 12 ft × 6 ft or 10 ft × 6 ft this size being easily handled by two men. The framework timbers of a 12 ft × 6 ft section are subject to considerable stress and it is necessary to use 6 in. × $1\frac{1}{2}$ in. timbers if bowing is not to occur. If wire mesh is used as the main floor component, 3 in. × 1 in., 10 or 12 gauge wire will prove satisfactory. At the moment there is no evidence to suggest that galvanizing is necessary. It is advantageous to place 2 in. × 2 in. perches above the wire at 18 in. centres. Observations show that at any one time about 70 per cent of the birds are on the perches, and this probably helps to prevent foot troubles developing.

Slatted floors may be used with equal success. Many shapes and sizes of slat are available but probably the most commonly used is the $1\frac{1}{4}$ in. width with $1\frac{1}{4}$ in. spacing between slats.

WIRE OR SLATS ?

The choice between wire and wooden slats is still debatable. Advocates of wire claim that it has a longer expectation of life than slats, but this contention has not yet been confirmed in practice, particularly where knot free wood is used. Wooden slats are certainly softer to the feet than wire, but as already mentioned perches above the wire will obviate this difficulty. However, there is a greater chance that external parasites may get a foothold amongst slats than on wire floors. On a question of cost, there is very little difference.

Labour Economy

The layout of the laying house is important if a man unit of 10,000 birds is to be achieved. The house should be served by a food and egg room which can be situated centrally or at one end of the house. The central room has the advantage that it divides the house into two completely separate units, which enables stock of different age groups to be housed. On the other hand, the end room means a lower capital outlay on feeding equipment as only one feed hopper is required. Further cost may be saved with the end-room design if more than one house is in use, because all bulk food bins will be on the hard road running along the front of the house.

ROLLAWAY NESTS

From the food and egg room a central service passage, 4 ft wide, should run the length of the house. Backing on to this gangway will be wire floor rollaway nests. These may have plasticized $\frac{5}{8}$ in. woven mesh floors or wire mesh floors. The former require a slope of 2 in. in 1 ft, the latter 1 in. in 1 ft. The plasticizing helps to prevent hair cracks which can cause a high percentage of second grade eggs. Hair cracks can be further reduced by limiting the rollaway distance to 10 in.

AUTOMATIC FEEDING

For units of 1,500 birds or over an automatic feeder may be economically employed. An allowance of 3 in.–4 in. of trough space should be given per bird and the feeder set to run for 40 mins and "off" for 100 mins. The speed at which the chain moves is of course dependent on the length of trough, but for a flock of 2,500 birds using about 310 ft of trough, a chain speed of 8–10 ft per minute will be adequate.

To prevent wastage, the trough should be set 7 in. above floor level. The movement and constant stirring of the food helps to maintain the birds' interest and may be instrumental in preventing feather picking and cannibalism.

Environmental Conditions

Ventilation in a windowless laying house is of great importance. Fans set in the ridge should be capable of a maximum extraction rate of $1\frac{1}{2}$ cu. ft of air per lb live weight per min. A speed control will be needed so that this extraction rate can be cut to one-sixth during winter conditions. A thermostat may be used as a supplement to this so that, if the temperature rises above 60°F, the fans are brought in. It is most

important that temperature is not maintained at the expense of fresh air, because humid, stuffy conditions predispose to respiratory troubles.

A temperature above 80°F will depress appetite and consequently cause a drop in production; egg-shell texture may also be affected. An inlet area of 5 sq. ft per 1,000 cu. ft extracted is recommended. Controlled inlets may be provided at eaves height, with the air baffled down on the inside to within 18 in. of the floor.

SEXUAL MATURITY AND LIGHTING PATTERNS

Lighting in a windowless house is normally provided by tungsten filament bulbs, the amount and intensity of light being of vital importance. Dr. R. Coles discussed the light problem in detail in the N.A.A.S. Quarterly Review of Autumn 1959. Some of the larger egg producers in Wiltshire find that rearing on a constant 12 hour day, and then increasing at point of lay by 20 mins per week up to 15 hours has proved most satisfactory. The object is to delay sexual maturity and make sure the bird comes into lay in good body condition. The relatively slow increase in day length means that the birds reach peak production slowly and losses from prolapse are greatly reduced. Also, birds coming into lay in good body condition are able to maintain peak production for a longer period. The total amount of light may be increased to 17 hours towards the end of the laying period to "squeeze" a few extra eggs from the bird.

WATERING

Water can be provided by a variety of small drinking troughs or by a continuous trough down the centre of the pen. Whatever means is used it is important to space the troughs so that the birds do not have to walk more than 8–10 ft to water. At a stocking rate of 1 sq. ft per bird, which is now common practice, it is essential to ensure that birds do not need to push through the mass of their fellows to drink, for a drop in water intake will result in a drop in egg production.

Other Aspects of Management

Most food compounders now include all the required calcium in the mash and it is not necessary to provide supplementary feeds. Flint or granite grit should, however, be fed once per week in tube feeders.

Rearing pullets for a windowless house is more easily carried out in an intensive windowless house. This greatly reduces the labour problem and enables reducing light patterns to be used. Results achieved by intensive rearing can be equally as good or better than range rearing.

It is obvious that with all the automatic equipment and use of artificial lighting and ventilation a power failure could have disastrous consequences. A stand-by generator is therefore essential.

Pullets must be debeaked when they are housed, which is normally at 16 weeks of age; this gives the birds time to settle down before they start to lay. Straw or hay is placed in wire floor nest boxes to encourage use and as one nest becomes more popular the litter material is removed to encourage even distribution.

Culling of the flock is not recommended as long as the level of production is regarded as satisfactory. The labour involved and the disturbance of the birds far outweighs any advantages. The same applies to broodies unless, of course, they become very numerous.

Flies may be a problem, particularly during summer months. The best method of control would be to spray the surface of the droppings, if this could be done without disturbing the birds. An alternative control procedure is to use a pyrethrum-based insecticide applied as a fine spray from a mist generator at weekly intervals. As this technique may be used over a considerable period the possibility of the development of resistance should be borne in mind.

HYGIENE

The value of a complete and thorough clean-out at the end of the laying year cannot be over emphasized. Accumulated droppings can be removed with a tractor and foreloader; floors and equipment should be cleaned and disinfected. Dust may be removed from the house with a suction machine and, when all the equipment has been replaced, the house should be fumigated and sprayed with an insecticide.

The wire and slatted floor system of housing layers has proved very successful in practice and hen housed averages of 220–250 eggs per bird are frequently reported. However, modifications and improvements will be made in the near future. We have yet to find a rollaway nest that eliminates cracks, a water trough that does not spill, and a simple means of dealing with the bane of all poultry farmers—manure.

Estimated Costs

The absence of any controlled experiments offering a comparison between output levels and costs of wire-floored houses and those of cage batteries or deep litter houses precludes a strict assessment of the merits of this new form of poultry housing. What information can be gathered from those poultry farmers who have changed from one or other of the more conventional forms of housing to wire floors is limited and must be treated with some reserve, as it will be appreciated that these people are invariably those who have adopted the new methods as a result of initial success and continued to operate them with a degree of enthusiasm.

From these limited data the following average figures are based:

	Wire Floor	*Deep Litter*	*Cage Battery*
Capital Cost	30s. (sq. ft)	10s. (sq. ft)	30s. (bird)
Sq. ft per bird	1·10	3·0	0·85
Labour per bird	1s. 4·4d.	2s. 1·1d.	3s. 1·0d.
Net profit (per bird)	26s. 9d.	19s. 0d.	17s. 0d.
Return on £1 capital invested	42 per cent	25 per cent	24 per cent
Gross return £1 labour	£49	£34	£22

Most of the figures are taken from an account by P. J. W. Lee at the 1961 Conference of the U.K. Branch of the World's Poultry Science Association and, as suggested above, should be regarded as only a very general indication of the relative costs of the several systems cited.

Nevertheless the high return on invested capital does seem a consistent characteristic of this new housing method. A more accuracte comparison may be achieved as a result of the work on a comparison between deep litter and wire mesh floored houses projected at one of the Ministry's Experimental Husbandry Farms.

Materials Handling in Agriculture

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THE IMPORTANCE of the share of labour costs occasioned by handling and transport operations—"lift and shift"—is now receiving wider appreciation than obtained two or three years ago. Little reflection is required to show how much of agricultural and horticultural work involves the movement and associated handling of a variety of materials —soil, fertilizers, dung, feedingstuffs, litter, and crop and animal products for marketing.

In manufacturing industry and goods distribution, "materials handling" is now a recognized specialist study, for in industry it is appreciated that at least one-third of the wages bill is the estimated cost of handling materials. Fleming (1960) has recently shown that on a 100 acre dairy farm, 1,150 tons of various commodities normally encountered on such a farm require to be picked up, moved and put down each year. By applying current handling and processing methods it was found that the "tonnage actually handled" was 8,801 tons—equivalent to the contents of 740 trucks each containing 12 tons.

Application of Principles

To what extent can the principles of materials handling be applied in agriculture? It is necessary first to make the point that materials handling is not necessarily synonymous with mechanical handling. Rather mechanical handling should be looked on as a means towards efficient, well designed movement of materials. Completely mechanized handling systems are quite feasible for some handling processes so far as the engineering side is concerned but may be impracticable from an economic or management standpoint. All too often the first approach to improving handling problems is to look for some form of mechanical equipment to supply the required improvement, instead of first questioning the necessity for the movement, the alternatives available and the cost using the present method. Mechanization may overcome handling problems but it may also increase cost unless the present method is carefully assessed first. In horticulture especially, an all too frequent "improvement" is the purchase of lengths of roller conveyor, without due regard to the considerations of putting on and lifting off, length and gradient.

Organized thinking costs less than equipment and will surely lead to more effective spending, should this be necessary. The fundamental attitude of mind to materials handling problems therefore should begin with:

1. *Elimination* of unnecessary handling, both in times handled and distances moved;
2. *Minimization* of remaining movement, e.g., by combination and variety reduction;
3. *Mechanization* provided this is practicable and economically worth while—but only after elimination and minimization.

As a guide to decisions on mechanization, and as a means of ensuring evaluation of the many considerations involved, the following check list (Van Ardall, 1957) may be helpful.

1. What is the initial cost of the equipment?
2. What is the annual cost of owning and operating it?
3. What are the possibilities of making more effective use of existing facilities rather than purchasing new ones?
4. What is the value of labour that would be replaced by proposed equipment?
5. How much labour will the equipment save?
6. What effect would the proposed equipment have on the cost of other inputs, or on the quantity and quality of the products?
7. What effect will the equipment have on the organization of the farm business in terms of labour distribution and size and type of enterprise?
8. Is the equipment suited only to one specific purpose or will it be usable for several different operations and enterprises?
9. Will the new equipment contribute to an integrated system of production in view of existing and planned facilities?
10. What are the opportunities for, and possible returns from, investing the initial cost of the proposed facility in some other part of the farm business?
11. Will the added equipment contribute to making the business easier and more satisfying?

Put another way the *first* consideration is Why (is this material moved from A to B) not How (can we move it from A to B).

Possibly the most significant example of elimination was the introduction of self-feed silage. Further scope is provided by the application of normal farm management techniques—reducing the number of crops grown leading to reduced handlings. Changes in the methods of feeding and mucking-out may require consideration. Thus the dung midden counters the principles of materials handling, since it is putting down to have to pick up again. Similarly zero grazing calls for increased handling, but there are often other factors to be borne in mind. On minimizing essential movement one should consider such items as grouping or concentration of stock—small lots in odd corners mean men carrying materials about unnecessarily, as does faulty positioning of stores in relation to where they are used. The broiler house with its built-in food store leads to "one man—many birds."

Some of the principles of materials handling (British Productivity Council, 1955) may be self-evident but are worthy of setting out:

1. minimize handling of all kinds—it adds only to *cost*, not to value;
2. never move more than once between processes, if possible;

3. combine the handling with the process—handling should never be considered in isolation from the operations or conditions leading to it;
4. study lay-out with the object of reducing the distance and number of times material is moved;
5. plan the process and put the building round it—decide on the size, shape and type of building *after* the handling processes are planned. As the Americans say, "Plan it, don't fix it";
6. carry out any processing operation during movement where this is practicable and safe;
7. arrange for suppliers to deliver in convenient units;
8. use the smallest practicable range of containers;
9. avoid putting loads of separate items directly on the floor—use pallets or stillages;
10. use gravity where possible, e.g., chutes; take advantage of slopes-loads down, empties up.

These principles are derived from industrial application, yet are readily applicable to farming, some more than others, though there are problems here not encountered in manufacturing industry. In particular the scale of many farm handling tasks is small, there are small lots of a wide range of materials of comparatively low value. Often the materials are difficult to deal with, e.g., dung, sugar beet, and have to be handled over surfaces that are uneven or muddy. Further, buildings are often poorly sited, because of piecemeal development, or of outmoded size and shape. All these factors combine against the efficient use of labour in handling tasks on and around the farm.

The tractor and trailer provides the most usual form of transport (in the sense of movement of materials from point to point) and copes well with the variety of materials to be moved and the adverse conditions obtaining. But trailers require loading and unloading and it is here that expensive use of labour may be seen. Further, lack of entry and exit facilities to buildings provides again for contravention of handling principles and thereby extra costs. Tipping and self-unloading trailers will improve matters here, but for maximum efficiency will require to be related to their method of loading and what happens on discharge.

In industry the technique of the unit load handled on pallets or stillages is well established. In effect a pallet or stillage becomes a movable portion of floor—important where numerous separate items of materials or containers are involved in picking up and putting down. A stillage is primarily a device for handling whereas a pallet should be of standard dimensions to allow for stacking on top of each other in storage. Their use offers many advantages, e.g.,

1. pallets can often be made on the farm;
2. pallet systems offer a means of satisfying many of the handling principles set out above;
3. use can be made of the hydraulic systems available to the farm tractor with obvious economic advantages;
4. manual lifting is eliminated—more is moved in less time with less effort.

The use of bulk containers and unit load devices has so far found several lines of application. These include bulk bins and pallet loading

for apples, handling of potatoes and vegetables from field to store or packing shed and bale handling for hay and straw. Thus the use of bulk bins for apples increases the carrying capacity of a trailer by 10–15 per cent over bushel boxes and up to 25 per cent over orchard trays. The use of 5 cwt pallet boxes for bulking up potatoes after picking is now well established in some areas and some large scale producers are handling 10 cwt boxes which then form a storage container. With hay there is the use of the bale sledge to give units of 16 bales. Each unit is then picked up by a trailer or carried direct to storage.

Besides the saving in time and effort which such systems offer, there can be a reduction in damage due to bruising caused by individual containers being manhandled so many times, particularly with a commodity such as apples. Labour saving is not the only criterion here —quality control is essential at every stage when evaluating new techniques (Culpin, 1960). Other applications are possible, e.g., handling and storage of purchased materials such as fertilizers, movement of feeding-stuffs from mixer to stock and so on. In horticulture a good deal of the loading of lorries for market is done at the end of the working day, often in overtime, and thus offers scope for improved handling technique. There are long-term considerations too—the introduction of mechanized handling in wholesale markets and the likely demand from large-scale buyers of standardized loads integrated with handling methods at the unloading stage.

Summary

The share of costs which can be set against materials handling in agriculture is high enough to warrant the immediate application of the principles of materials handling to all handling operations into, on and from the farm. This consideration will acquire greater importance with every increase in labour costs, for in many farming tasks it is the make-ready and put-away, the pick-up and put-down which is costly. It is accepted that poor handling methods derive very often from the lay-out and design of buildings, thus leading to the work routines and work flow being determined by the buildings and equipment available. So with new buildings the best handling system should be planned at the drawing board stage of planning. This affords opportunity to integrate such factors as floor surface and strength, doors, passageways, vehicle access and storage with the movement of the materials required for the enterprise. The use of handling equipment is bound to increase on a scale determined by individual circumstances and economic justification. Nevertheless the principles of materials handling are applicable whatever the scale of the operations.

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Regional Notes

Water Supplies in the Yorks/Lancs Region

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THIS NOTE deals mainly with the problem of advising on water supplies for milk production, but a suitable and plentiful water supply is important in every farm enterprise, whether it be for domestic use, milk production, livestock rearing, crop irrigation, or horticulture.

Sources of Water

Contrasts in geological formations cause the water supplies in the Yorkshire/Lancashire region to differ considerably from one area to another. Good underground sources, reliable in quantity and pure in quality, are given by the chalk formations of the East Riding and by the Triassic Sandstones (Bunter and Keuper) underlying the western part of the East Riding, parts of the West Riding and in west Lancashire. In contrast, the Millstone Grit of the Central Pennine area and part of Lancashire, yields a number of springs but is generally rather impervious. Its main importance lies in the abundant surface run-off which, assisted by the high rainfall and thick layer of water-holding peat covering much of the moorland, has resulted in the area being extensively used as gathering grounds for many nearby town supplies. A different type of water is found in the Carboniferous Limestone areas in the north of the West Riding and Lancashire. This formation is heavily fissured and springs occur of all volumes from a mere trickle to a decided river, but the water is frequently of poor bacteriological quality due to the size of the fissures and the numerous swallow holes. Finally, in the coal measures of the West Riding and south Lancashire, water sources occur mainly as springs, but the quantity tends to be unreliable in dry periods and more reliance is placed on mains supplies in those areas.

Public mains supplies extend to most parts of the region, particularly near industrial development, but of course there are still many remote areas where the farmers cannot obtain mains water at an economic cost. An accurate figure for the proportion of farms which have a public supply is hard to obtain, but it has been estimated that over 90 per cent of the milk producing farms in the East Riding are connected to public mains, whereas the corresponding figures for Lancashire and the West Riding are thought to lie somewhere near 75 and 60 per cent respectively.

Water Supplies for Milk Production

It is of the greatest importance that water supplies used for milk production should not only be adequate in yield but also bacteriologically

suitable, in order to safeguard the milk from risk of bacterial contamination from water. Consequently, all supplies (other than mains) on registered milk premises, or on farms where it is desired to produce milk, are inspected by milk officers and samples are examined bacteriologically in the Milk Service Laboratories. The results of the samples and a field report on the water supply are forwarded to the N.A.A.S. Regional Advisory Bacteriologist who advises on the suitability of the supply for dairy purposes. In the year ended 31 March, 1961, 2,255 water samples from approximately 1,395 supplies were examined in the region.

Table 1 shows the sources of the water supplies examined that year and it is interesting to see that four-fifths of the supplies in Lancashire and three-quarters of those in the West Riding were from springs, while the comparatively few milk producing farms in the East Riding, which are not on mains water, are mostly supplied by boreholes.

Table 1

Water Supplies examined in Year Ended 31.3.61

	Lancs	East Riding	West Riding	Total
Springs	399	8	610	1017
Boreholes	1	32	68	101
Wells	52	1	61	114
Streams	31		48	79
Stone drains	15		18	33
Miscellaneous	21	2	28	51
	519	43	833	1395

Bacteriological Quality

The bacteriological quality of water supplies on farms is highly variable. Most boreholes, many springs, and a smaller proportion of wells, are of good quality at the source and are either suitable or can be made suitable for dairy purposes. A number of supplies, however, are found to be in an unsatisfactory condition, and in a recent analysis it was estimated that about one-third needed improvements of a major or minor character before they could be considered suitable.

When a supply is found to be contaminated, every effort is made to find the cause of the contamination and to suggest ways of removing it. If the cause is obvious from the milk officer's report, advice can be given immediately, but very often further investigation of the supply is necessary and in difficult cases more than one follow up visit may have to be made to obtain the fullest possible information on the source and distribution system. The adequacy of the supply also has to be con-

sidered and, if the yield is unreliable or insufficient, the farmer is advised to obtain a better alternative supply if possible.

Unsatisfactory supplies fall into two groups:

1. those which are contaminated at source and on which little or no improvement is possible;
2. those which are pure at source but which undergo contamination through a faulty collecting or distribution system.

Fortunately comparatively few supplies fall into the first group and when they occur every effort is made to find a suitable alternative.

The second group is far greater and the causes of contamination are various. They include defects in the source works, piping and storage tanks, and inadequate fencing of the source area and tanks from stock or poultry. Most frequent perhaps is the poorly constructed collecting or storage tank which allows surface or soil water to enter through the sides or top. Such tanks can generally be made impervious by grouting, rendering, raising the walls above ground level and fitting a watertight cover, but in bad cases complete reconstruction may be necessary. It is often found that a spring has not been collected properly at the source or that no-one knows where the source is. Tracing the source so that it can be protected in a suitable collecting chamber and fenced from stock can be laborious, but is well worth while for the resulting improvement in the bacteriological quality of the water.

It is necessary to emphasize the importance of good materials and workmanship in the construction or renovation of water supply systems, so that they do not quickly fall into disrepair but can easily be maintained in good condition.

There is a proportion of supplies which for one reason or another still show some bacterial contamination even when all reasonable protection has been given. If it is considered that dangerous pollution is unlikely, it may be possible to recommend that these supplies can be used in the dairy, provided the water is effectively treated either by boiling or (more usually) by addition of approved hypochlorite solution.

Local Problems

As in most regions, there are some special local problems in Yorkshire and Lancashire. Mention has already been made of the springs in the fissured limestone which are often contaminated. Here it is necessary to study the topography most carefully to assess the risk of human or dangerous pollution and, even when obvious sources of contamination have been eliminated, treatment of these supplies is usually necessary.

Fell and moorland streams, the only available water for many farms in the Pennines and north Lancashire, are another difficult problem. The source may be several miles from the existing draw-off point and it is frequently uneconomic to pipe the water from the source. Great care is again necessary to assess the risks of pollution and, if the water

can be piped from above the cattle line, sufficient improvement may be brought about for some of these supplies to be used for dairy purposes provided the water is treated.

Thirdly, there are the lengthy stone drain supplies which are so common in parts of the Pennines. They often start as perfectly good springs on the moor but become contaminated as they travel down the hillside in ancient stone drains, passing in and out of cattle troughs, the overflow from one farm passing down to the farm below. While it is easy to advise that the supply should be properly piped from the source, by-passing all troughs and providing a suitable distribution scheme for all the farms involved, the economic, legal, and social difficulties are sometimes so great as to make this impossible to carry out, and it is better to try to find an alternative supply.

Chemical Problems

The chemical properties of the water supplies occasionally give problems. Excessively hard waters are not very often found in this region, but soft acid water from the peaty areas is liable to dissolve copper from pipes and cylinders and this can lead to serious corrosion of aluminium vessels. Water containing iron salts which precipitate out when the water is aerated, is found from time to time, but this problem can often be dealt with by passing the water through a tank containing limestone chippings.

Grant-aided Schemes

For many years the Drainage and Water Supplies Department has assisted farmers with grant aided schemes to bring mains water to farms or to develop new private supplies for domestic and agricultural purposes. The majority of schemes have been for milk production or livestock rearing and a few for horticultural purposes, but recently, particularly in the East Riding, there has been an increase in schemes for irrigation, often requiring the sinking of a new borehole.

Drainage and water supplies officers also co-operate in advising milk producers whose dairy water supplies need extensive or costly improvements. The technical assistance of D.W.S. officers, and the grant aid which can sometimes be arranged to meet the cost of improvements, have helped greatly towards the solution of many difficult water supply problems.

Summary

Some indication has been given of the complexity of farm water supplies and the care necessary in giving sound advice on improvements. A number of milk-producing farms are still without a suitable and sufficient supply and on some of these, for economic or other reasons, a solution may be hard to find. Nevertheless steady progress is being made and, with the co-operation of milk officers, water supplies officers and the farmers themselves, it is hoped that the majority will eventually obtain a good and sufficient supply.

Spraying Trials in Relation to Copper Deficiency in Lancashire

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RECENTLY Morgan and Clegg (1958) described occurrences of copper deficiency in both dairy and beef cattle in Lancashire. Attempts to control the disorder by spraying grassland with copper compounds were also reported. Some success was observed by spraying copper sulphate solution together with the provision of a box of copper rich mineral supplement in the field for voluntary consumption. Whilst this treatment proved successful, analytical data for treated herbage were disappointing in that the level of copper in treated herbage was increased for one defoliation only, after which levels reverted to those found in untreated pasture. To observe these effects over a number of years, a further 2 years of observation have been made on the influence of spraying copper compounds on the copper content of herbage. These results are recorded below.

1958 Trials

These were conducted in a similar manner to those of previous years, but copper sequestrol was introduced as one of the treatments in addition to copper sulphate. Sequestrols (or versenates) are used in plant nutrition for the control of foliar chlorosis. They are complexes of metals with ethylene diamine tetraacetic acid, but the metal is held in co-ordinate linkage and is not ionized in solution. The aim was to see if copper sequestrol would increase the copper content of herbage for a longer period of the summer grazing period and not just for the first defoliation. The treatments consisted of:

a. Control

b. 6 lb of hydrated copper sulphate sprayed in 100 gallons of water per acre

c. 12 lb of hydrated copper sulphate sprayed in 100 gallons of water per acre

d. 10 lb of copper sequestrol sprayed in 100 gallons of water per acre

Treatments *b.* and *d.* provided the same amount of copper.

Herbage cuts were taken regularly throughout the summer at approximately 4–5 weekly intervals. The summarized analytical results for the dry matter of the herbage are given in Table 1. Each figure represents the average for triplicate samples at each cut.

The effect of copper sulphate at both levels was rather surprising in that copper contents were initially raised to much higher levels than those previously observed. It might be suspected that these high

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Table 1

Copper, Molybdenum, and Inorganic Sulphate Contents in the Dry Matter of Treated and Untreated Herbage (1958)

Treatment	Cut no.	Date	Copper (ppm)	Molybdenum (ppm)	Inorganic sulphate (per cent SO_4)
a	1	29.5.58	8·4	4·7	0·52
	2	2.7.58	9·8	4·3	0·69
	3	12.8.58	6·1	3·5	0·58
	4	12.9.58	8·6	3·9	1·08
b	1	29.5.58	60·0	3·5	0·59
	2	2.7.58	10·4	4·8	0·83
	3	12.8.58	6·7	3·9	0·85
	4	12.9.58	9·8	5·0	1·26
c	1	29.5.58	80·0	3·5	0·61
	2	2.7.58	10·7	4·3	0·85
	3	12.8.58	6·7	4·8	0·84
	4	12.9.58	10.1	4·3	1·23
d	1	29.5.58	20·0	4·1	0·52
	2	2.7.58	10·0	5·2	0·67
	3	12.8.58	8·2	4·0	0·58
	4	12.9.58	8·9	5·2	0·99

copper contents were indicative of leaf surface contamination, especially since areas sprayed with copper sulphate showed considerable scorch, although this was absent on the copper sequestrol sprayed area. But surface contamination was ruled out because the effects were shown during fairly heavy rain, and the weeks following spraying were noted for their wetness.

The fact that such high copper contents can be recorded is a further indication of the need for caution in the use of copper compounds. Comparatively low intakes of copper have been found by Ogilvie (1954) to produce chronic poisoning in sheep, and similar effects have been noted by Shand and Lewis (1957) in calves. The use of high rates of copper sulphate sprayed on a large proportion of the grazing areas of farms could mean in some seasons a prolonged period of grazing herbage of high copper content that might be dangerous for sheep or calves. Here only a small proportion of the total grazing area was treated with copper compounds during 1958, and no toxic or deficiency symptoms occurred in calves grazing the area.

Following the first cutting, the pattern of copper levels was similar in all treatments and confirmed previous results. It appears that copper sequestrol is not as efficient as copper in an ionic form. Molybdenum and inorganic sulphate contents were similar to the levels recorded in other years, and were sufficiently high to be considered critical and to limit copper storage.

1959 Trials

Since the 1958 trials had not shown any advantage in using copper sequestrol, the 1959 trials reverted to a simple study of the effect of applying 6 or 12 lb of hydrated copper sulphate per acre. Unfortunately as in the 1957 season there was a period of severe drought and only 2 cuts were obtained. The results were very similar to those of the 1957 season and are summarized in Table 2.

Table 2

Copper, Molybdenum, and Inorganic Sulphate Contents in the Dry Matter of Treated and Untreated Herbage (1959)

Hydrated copper sulphate lb/acre	Copper (ppm)		Molybdenum (ppm)		Inorganic sulphate (per cent SO_4)	
	1st Cut	2nd Cut	1st Cut	2nd Cut	1st Cut	2nd Cut
0	9·6	10·8	2·3	1·7	0·44	0·80
6	9·2	10·2	2·7	2·5	0·69	0·91
12	9·6	9·9	2·4	2·4	0·62	0·98

The molybdenum contents were rather lower than in previous years, possibly because it was necessary to use a different field for the 1959 trials.

Summary

From the results of four sets of trials spread over four seasons it is clear that the effectiveness of treating herbage with copper sulphate to raise herbage copper levels varies considerably from season to season. Further, any increases obtained are short lived and are apparent only for the first defoliation or grazing of sprayed grassland, after which copper levels return to those of untreated areas. In some years it is not possible to measure any increase in herbage copper. On the other hand, increases that might be dangerously high for sheep and calves might be recorded in other seasons. There appears to be no advantage from the use of copper sequestrol instead of copper sulphate.

Although some success had attended spraying plus the provision of free choice copper rich minerals in preventing copper deficiency on the farm where these studies were conducted, general acceptance of this technique is ruled out because of the variable results between seasons, coupled with the high cost of spraying operations. For this reason the use of copper glycine injections have been studied. This is now the recommended method of providing additional copper, and results of trials with copper glycine will be reported elsewhere.

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